AN IMPROVED METHOD OF PRICING FAT AND NONFAT SOLIDS IN MILK

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AN IMPROVED METHOD OF PRICING FAT AND NONFAT SOLIDS IN MILK

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SUMMARY

The study was undertaken with the principal objective of developing more accurate and equitable procedures for establishing price differentials for fluid milk based on differences in the fat and nonfat solids content.

For many years milk prices took into account only the fat content. Nonfat solids were generally ignored in setting milk prices because of their negligible market value. In relatively recent years, however, this situation has changed. Skim milk in most milk markets now has appreciable values and appears to be continuing to rise in value in relation to milk fat values. In spite of this, pricing plans in many markets fail to provide for an automatic adjustment of milk prices to the changing relative values of the two major components of milk. Although inaccuracies and inequities in pricing probably are serious in only a few markets at present, failure to modify prices in accordance with changing marketing conditions can create imbalances in supplies of milk fat and nonfat milk solids and other marketing inefficiencies.

Two formulas for establishing milk fat differentials were developed. One of these establishes differentials to be used in conjunction with use-class prices paid by handlers. The other sets differentials for producer (blend) prices. The two formulas are alike in that both are based on market values of butter and nonfat dry milk solids. The main difference is that the handler differential takes account of the fact that the percentage of nonfat milk solids in milk declines as the milk fat percentage increases during the process of standardizing milk to a particular fat test. The recommended formula for handler differentials for milk in manufacturing use-classes is: (1) multiply the net plant price of butter by 0.122 and (2) subtract from this product the product of the net plant price of nonfat dry milk solids and 0.009. For fluid milk classes the recommended differential is the manufacturing use-class differential multiplied by the ratio of the basic fluid milk class price to the manufacturing milk class price,

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In the formula for the producer differential the value of a small quantity of nonfat solids is added to the fat value because in natural milk the percentage of nonfat milk solids increases as the fat percentage increases, but at a lesser rate. It is also desirable to deduct a small manufacturing cost allowance because high-test milk costs slightly more to process into butter and powder than does low-test milk. To compute the producer differential: (1) multiply the net plant price of butter by 0.122; (2) add to the result of (1) the net plant price of nonfat dry milk solids multiplied by 0.042; (3) subtract a manufacturing costs allowance of 0.1¢; and (4) increase the differential thus computed by the ratio of the blend price of milk at the average test of milk received in the market (or plant) to the butter-powder value of milk of equal test.

Complete details of the formulas and a full discussion of the principal reasons for choosing each of their several components are set forth in this report (pages 8 to 17). The recommended formulas are designed more for the future than for the present. Milk fat differentials in only a few city milk markets are now seriously out of line with current economic conditions affecting values of milk solids. The principal merit of the formulas, however, is their capacity to alter automatically the relative prices of milk of various solids content as future economic developments change relative market values of milk fat and nonfat milk solids.

THE PROBLEM

This study was undertaken to re-evaluate current methods of pricing fat and nonfat solids in milk and to develop more accurate and equitable methods. The study is primarily concerned with pricing techniques employed in fluid milk markets to establish price differentials based on differences in the solids content of milk.

The need for re-evaluation of existing methods of pricing milk on the basis of solids content stems basically from the rising demand for nonfat milk solids in relation to the demand for milk fat. For this reason, there is need of a pricing plan for fluid milk markets that will alter milk price differentials based on the solids content of milk promptly and accurately as future economic developments require. Failure to modify many existing fluid milk pricing plans may, in time, create serious imbalances in supplies of milk fat and nonfat milk solids, and cause other marketing inefficiencies.

In the long history of fluid milk pricing several basic changes have occurred in methods of establishing price differentials based on the solids content of milk. Prior to the beginning of this century the typical basis for pricing milk was volume without regard to solids content. Then, about 60 years ago, Stephen M. Babcock developed a

practical test for the fat content of milk. This test permitted buyers to pay farmers for milk on the dual basis of fat percentage and weight.

At the time the Babcock test was developed, and for years thereafter, milk fat was the only portion of milk with substantial market value. Butter was the principal product of the dairy industry. Inadequate transportation and refrigeration facilities and other factors compelled conversion of most of the milk produced in this country into this more concentrated and less perishable product. At times, and in some producing areas, skim milk had even negative values. For these reasons, it was natural that the nonfat solids content of milk generally was ignored in establishing milk prices.

Today the situation is sharply different. Skim milk in nearly all parts of the nation has appreciable market value. Directly responsible for these changes in milk fat and nonfat milk solids price relationships are the declining consumption of butter and the increasing consumption of other major types of milk products. And among the principal factors underlying these changes in milk uses, and hence in the relative values of fat and nonfat milk solids, are changes in eating habits, development of new dairy products, improvements in product qualities, increasing importance of competing products (especially margarine and mellorine), and major changes in technologies of assembling, processing, and distributing milk and milk products. Therefore, revisions of some of the pricing techniques in fluid milk markets are needed to take account of the changing values of the two major components of milk.

OBJECTIVES

This study has two major objectives. The first is to develop an improved method of pricing milk of different fat and nonfat solids contents that accurately reflects "true" relative values of the two types of solids in milk and fluid milk products. The second objective is to evaluate this method, in relation to current pricing methods, from the standpoints of pricing efficiency and equity.

PROCEDURES

In the course of this study pricing methods used in fluid milk markets were studied with special attention to techniques of fixing prices for milk of various fat tests. Literature bearing on pricing fat and nonfat solids in milk was reviewed. Studies of processing costs were examined. From this and other information a pricing method was developed. This method was then compared with a number of current plans.

ADJUSTING MILK PRICES FOR SOLIDS CONTENT

In nearly all markets the price of milk is based on its composition as well as on such other factors as final use, quality, and location of producers. The number of plans for varying prices in accordance with variations in the solids content of milk is large, but nearly all may be classified among 4 principal groups.

Hundredweight Plan

The most common method is generally known as the hundredweight plan. This plan has three main features: (1) a standard test for milk, say, 4.0 percent fat, for accounting and pricing purposes; (2) use-class and producer blend prices for standard-test milk; and (3) a milk fat differential for each class and blend price.

In pricing milk of various fat tests the price of standard-test milk is the starting point. Next, the difference in points (a point equals a fat test of 0.1 percent) between the standard test and the test of the milk being priced is computed and this difference is multiplied by the amount of the price differential. The resulting value is added to the standard-test price if the test of the milk is greater than the standard test, or subtracted if the milk has a lower test than the standard. For example, if the standard test is 4.0 percent, the standard-test price is \$5.00 per hundredweight, and the butterfat differential is 8 cents, then the price of milk testing 4.5 percent fat is \$5.40, and the price of 3.5 percent milk is \$4.60.

"Fat-Skim" Plan

Milk is priced in some cities on a "fat-skim" basis. In most of these cities the plan applies only to class (dealer) prices and the hundredweight plan is used to vary blend (producer) prices. Under the "fat-skim" method, a pair of prices is established for each use class, a price for milk fat and a price for skim milk. The value of 100 pounds of whole milk is the sum of the skim and fat values. For example, if the price of skim milk is \$1.80 per hundredweight and the price of milk fat is \$81.80 per hundredweight, the price of 100 pounds of 4.0 percent milk is \$5.00. This is the fat value of \$3.272 (\$81.80 x .04) plus the skim value of \$1.728 (\$1.80 x .96).

Although this pricing method differs materially in several ways from the more common hundredweight plan, the two methods can provide identical schedules of prices for milk of all possible fat tests. 2/

Simple Fat Pricing

The simplest form of pricing milk on the basis of fat content, still used in a few city milk markets, involves no price for milk as such, only a price for milk fat. In computing milk values under this method no consideration need be given to the volume of whole milk or skim milk since only milk fat is priced. 3/ When prices are quoted per hundredweight of milk, they will vary in direct ratio to the fat tests. This method of pricing, therefore, becomes identical with a hundredweight plan having a direct-ratio fat differential. For example, a price of $1.25 per pound of fat provides the same schedule of prices for milk of all fat tests as a hundredweight plan with a price of $5.00 per hundredweight of 4.0 percent milk and a fat differential of 12.5 cents per point. 4/

Milk-Equivalent Plan

In unmodified form, a milk-equivalent plan is essentially the same as a simple fat pricing plan or a hundredweight plan with direct-ratio fat differentials. Only the techniques of price computation differ. The milk-equivalent method sets a price for milk of a standard test, say, $5.00 per hundredweight of 4.0 percent milk. Milk of other fat tests is then "converted" into "equivalent" quantities of 4.0 percent milk in direct ratio to the fat tests. For example, milk testing 4.4 percent fat "equals" 110 pounds of milk testing 4.0 percent fat and milk testing 3.6 percent fat is "equal" to 90 pounds of 4.0 percent milk. Only a few cities use this plan in its pure form but several use variants of the method, all of which accord some value to the nonfat solids in milk.

2/ To convert a "fat-skim" plan into an equivalent hundredweight plan: (1) compute the price of the standard-test milk in the manner illustrated above and (2) compute the amount of the fat differential by subtracting the price of 100 pounds of skim milk from the price of 100 pounds of milk fat and dividing the result by 1000. To convert a hundredweight plan into an equivalent "fat-skim" plan: (1) obtain the value of 100 pounds of skim milk by subtracting from the price of the standard-test milk the product of the fat differential and the number of fat points in the standard-test milk, and (2) compute the price of 100 pounds of milk fat by multiplying the fat differential by 1000 and adding the value of 100 pounds of skim milk as computed in (1) above.

3/ If a buyer using this pricing method accords any value to the skim milk in the whole milk or cream he buys he merely inflates slightly his price for milk fat.

4/ An identical series of prices is obtained under a so-called "fat-skim" plan having a price of $125 per hundredweight for milk fat and a price of zero for skim milk.

REQUIREMENTS OF A FEASIBLE PLAN

A plan for adjusting milk prices for differences in solids content should achieve approximate equality of the average solids tests of all milk received in a market with the average solids tests of all fluid products sold. That is, there usually should not be large shortages or surpluses of skim milk in relation to quantities of milk fat received. Other requirements of a practical plan are: (1) flexibility, (2) consistency with other parts of the milk pricing system, and (3) simplicity.

Balancing Supply-Demand Forces

Several conflicting forces must be equated (approximately) to achieve the practical objective of a workable balance between the average solids tests of milk received in a market with the average solids tests of the total of fluid products sold.

(1) Milk high in fat content almost always affords a milk distributor a higher gross return than low-fat milk in both fluid and manufacturing uses. This is because (a) in fluid uses, high-fat milk provides a higher-valued combination of products (a greater proportion of cream) per hundredweight of whole milk, and (b) in manufacturing uses, yields of finished products from high-fat milk are greater. For example, as shown in Table 1, 100 pounds of milk testing 4 percent fat yields nearly 4.9 pounds of butter and 8.5 pounds of nonfat dry milk solids, whereas 100 pounds of 4.5 percent milk yields about 5.5 pounds of butter and 8.7 pounds of skim powder.

(2) Although high-fat milk is worth more in the market place, it is also more costly to produce. Several studies of costs of producing milk on farms indicate this. The rate of increase has been determined to be in the neighborhood of 2 percent of the cost of producing 100 pounds of milk testing 3.5 percent fat for each point (0.1 percent) increase in the test. 5/

5/ Wright, K. T. and Baltzer, A. C.,"Profitable Dairy Management," Michigan Agricultural Experiment Station Special Bulletin 297, April, 1939; Hyre, F. M., "Butterfat Price Differentials for Fluid Milk," Rhode Island Agricultural Experiment Station Bulletin 248, 1935; and Misner, E. G., "Some Methods of Computing Butterfat Price Differentials," New York (Cornell) Agricultural Economics Bulletin 459, 1943. Since certain market changes, especially farm-to-plant transportation rates, usually are on a hundredweight-of-milk basis without regard to fat content, the higher cost of producing richer milk would be less than 2 percent of the city plant price of 3.5 percent milk per point increase in fat test.

Table 1.--Yields of butter and nonfat dry milk solids from milks of various fat tests

Solids tests		Yields per 100 pounds of milk	
Fat	Nonfat 1/	Butter with 22% overrun	Powder with 4% underrun
Percent	Percent	Pounds	Pounds
3.0	8.402	3.660	8.066
3.5	8.622	4.270	8.277
4.0	8.842	4.880	8.488
4.5	9.062	5.490	8.700
5.0	9.282	6.100	8.911
5.5	9.502	6.710	9.122
6.0	9.722	7.320	9.333

1/ Based on Jack, E. L., and others, "Relationship of Solids-Not-Fat to Fat in California Milk," Calif. Agr. Expt. Sta. Bul. 726, 1951.

(3) Even though milk distributors can obtain higher gross returns from high-fat milk, they do not generally attempt to procure milk having, on the average, a high fat test. Instead, they seem to prefer to receive milk with an average fat test falling within a relatively narrow range around the average fat test of all fluid milk products they sell.

The principal apparent reason for this preference is quite simple. A serious imbalance between average fat tests of milk received and of fluid milk products sold, frequently increases marketing costs and reduces marketing efficiency. If the fat test of milk received is too high, dealers will have either a shortage of skim milk or a surplus of fat depending on the total volume of milk received. (They might also have absolute shortages or surpluses of both, but there would be relatively more fat than skim in relation to requirements in any case.) If the fat test of milk received is too low, the opposite relationships will be present. In general, such imbalances in supplies and requirements force dealers to dispose of surplus milk fat or skim milk or to procure additional supplies of one or the other outside normal marketing channels. Such departures from customary practices frequently are costly in both measurable and intangible ways. Marketing efficiency, therefore, may be reduced.

Dealers, of course, have the additional alternatives of attempting to persuade consumers as a group to alter their established pattern of fluid milk product purchases or of inducing farmers to alter the solids tests of the milk they produce and deliver. Various techniques, including advertising and other promotional activities, might be used. These may be either more or less costly than the value

of benefits from them. In the long run, proper price differentials among milk and milk products of various solids tests are likely to be the most efficient device for approximately equating average solids tests of milk received and average solids tests of fluid milk products sold.

Flexibility

Another requirement of a feasible plan for adjusting milk prices on the basis of solids content is flexibility. This is important because economic conditions affecting dairy products markets are constantly changing. The probable result of price inflexibility is distortion of relative prices of milk of various solids content. In a period of unusually rapid and extreme changes in economic conditions, the pricing errors resulting from an inflexible plan may have serious consequences for a milk market.

Simplicity

Two other desirable features of a plan to vary milk prices on the basis of solids content are simplicity and compatibility. Simplicity is always preferable to complexity, provided that a simple plan can be devised that will have the degree of accuracy and flexibility in operation essential to a workable pricing plan. Such a plan must also function as a part of a larger pricing system. Therefore, it should fit into this system without creating internal inconsistencies in the whole mechanism.

THE RECOMMENDED PLAN

The plan recommended here for establishing prices of milk of various solids content is based on national market values of butter and nonfat dry milk solids and on known physical relationships in the solids content of milk. The plan uses the mechanism of the well-known hundredweight method of pricing milk. Although this recommended plan is similar to the one developed by Froker and Hardin 6/ it differs materially with respect to (1) taking account of the different relationships between fat and nonfat solids in standardized milk and in milk as it comes from the cow and (2) eliminating the allocation of "direct" marketing charges to the butter and nonfat dry milk solids price components in the formula for establishing butterfat differentials to producers.

6/ Froker, R. K., and Hardin, C. M., "Paying Producers for Fat and Solids-Not-Fat in Milk," Wisconsin Agricultural Experiment Station Research Bulletin 143, February 1942.

The procedure of this section is (1) to describe the plan in a general way, (2) to discuss reasons for employing each major feature, (3) to point out deficiencies of several common current pricing plans in comparison with the recommended plan, and (4) to present a final general appraisal of the plan.

Description

Two types of milk fat differentials are established under the plan. One type applies to prices paid by handlers (use-class prices) and the other to blend prices received by producers. One type of differential alone will not suffice for both purposes primarily because of basic differences in the physical relationships of fat to nonfat solids in standardized and unstandardized milks.

Producer Differentials

Computation of the producer price differential per point (0.1 percent) of fat test involves only two steps, and under certain circumstances the second may be omitted or modified. The recommended procedure is:

(1) Compute the butter-powder price differential by multiplying the wholesale price of butter by 0.122 (the assumed yield of butter from 0.1 pound of milk fat); add the product of 0.042 (the assumed yield of powder from the 0.044 pound of nonfat solids associated with an increase of 0.1 pound of fat) and the wholesale price of nonfat dry milk solids; and subtract from the above sum an allowance of 0.1 cent for the difference in manufacturing costs resulting from test variations in milk receipts. The method of establishing this allowance and the product yield factors, shown in Table 1, are discussed below.

(2) Adjust the above butter-powder differential by multiplying it by the ratio by which the producer blend price of milk at actual test exceeds the butter-powder value of milk of equal test. The result is the recommended producer butterfat differential per point of fat test.

The arithmetic of computing the producer fat differential is quite simple, as the example below shows. Assuming the price of butter at 57 cents per pound, powder at 15 cents and an allowance of 0.1 cent for the difference in manufacturing costs resulting from test variations in milk receipts, the producer fat differential is computed as follows:

(1) The butter-powder differential is:

$$(0.122)(\$0.57) + (0.042)(\$0.15) - \$0.001 = \$0.0748$$

which when rounded to the nearest tenth of a cent is 7.5 cents.

(2) The producer fat differential, assuming a blend price of \$3.60 at the actual test of 3.8 percent and a butter-powder value of \$3.20 for 3.8-percent milk is:

$$\frac{(\$3.60)(\$0.075)}{\$3.20} = \$0.0844\text{, or 8.4 cents } 7/$$

Handler Differential

Fat differentials applicable to use-class prices are computed in a manner basically similar to the above method used for producer differentials. The two steps in the computation are:

(1) Multiply the wholesale price of butter by 0.122 (the yield of butter from 0.1 pound of milk fat) and subtract the product of the wholesale price of nonfat dry milk solids and 0.009 (the average decrease in yield of powder associated with an increase of one point in fat test when 4-percent milk is standardized to other tests). The result is the butter-powder differential applicable to manufacturing milk.

(2) Adjust the differential resulting from (1) above by multiplying it by the ratio by which the use-class price of milk of standard test exceeds the butter-powder value of milk of the same test. This fixes the fat differential for each use class.

The value of the Class I fat differential paid by handlers, assuming that the Class I price for 4-percent milk is \$1.00 per hundredweight over the butter-powder formula value of \$3.35, is computed as follows:

(1) The butter-powder value of the handler differential is:

$$(.122)(\$0.57) - (0.009)(\$0.15) = \$0.0682\text{, or 6.8 cents.}$$

7/ Whenever the average test of milk received from producers differs from the standard test on which blend prices are quoted one more computation is needed to fix the standard-test blend price. This is because the amount of the differential and the difference between the two fat tests affect the amount of the quoted blend price. The procedure is: (1) multiply the differential by the number of points of difference between the two tests, and (2) add this amount to the blend price at the average test if the standard test is higher and subtract if the standard test is lower. In the above example, the blend price for a standard test of 4-percent fat is \$3.60 plus 2 times 8.4 cents, or \$3.768.

(2) The Class I differential is:

$$\frac{(\$4.35)\ (\$0.068)}{\$3.35} = \$0.0883, \text{ or } 8.8 \text{ cents.}$$

Discussion

A brief presentation of the facts and logic which support the plan, especially some of the less obvious features, is now in order.

Butter and Powder Prices

Wholesale prices of butter and nonfat dry milk solids are the primary economic values and movers on which price differentials under this plan are based. These prices (and products) were chosen for several reasons:

(1) Butter and nonfat dry milk solids are the only major dairy products that provide distinctly separate measures of the values of milk fat and nonfat milk solids. 8/ Prices of all other major dairy products--cheese, ice cream, evaporated milk, and fluid milk--reflect combinations of fat and nonfat solids values.

(2) Butter and powder are two of the major manufactured products that absorb surplus milk from fluid milk markets. In many city milksheds, plants producing butter, powder, and other manufactured dairy products compete directly or indirectly with city plants for milk supplies. Butter and powder prices, therefore, are good measures of the alternative costs of using milk fat and nonfat milk solids in fluid milk products. These prices are desirable movers in a pricing formula of the type being considered here to keep the relative prices of fat and nonfat solids in line with basic economic conditions affecting the dairy industry and to add necessary flexibility. It is largely for this reason that many fluid milk markets, especially in the North Central States, employ formulas based on the prices of butter, powder, and other manufactured dairy products to establish Class II (manufacturing) milk prices and to establish the basic formula prices to which Class I premiums are added in fixing Class I (fluid) milk prices.

(3) Wholesale prices are used in the recommended formula because they are, on the whole, the best available measures of butter and powder values for the purposes of this pricing plan. Although prices quoted or received at country points would be preferable to wholesale price quotations, such prices are not now reported with sufficient

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8/ There are also a few minor products that can provide separate measures of the values of the two types of milk solids, but prices of these products are not as generally reported and probably are less well suited in other respects for the pricing formulas described above.

accuracy, frequency, detail, and coverage for practical use in a formula of this kind. An exception to this is the reporting of powder prices at country points in the Chicago area. Retail prices have the additional disadvantages of being further removed than wholesale prices from plant prices and of reflecting a wider range of kinds and quantities of marketing services.

(4) Finally, it may be argued that formulas based on national market values of butter and nonfat dry milk solids will not provide satisfactory fat differentials in all local fluid milk markets. This may prove to be the case. But until further research on this point has been completed, it seems quite reasonable to conclude tentatively that in the case of fat differentials the recommended formulas will prove satisfactory in most markets. This is especially true for fat differentials applicable to Class II prices and probably also to producer differentials. In a few markets it is quite possible that unusual local conditions will call for modification of the differentials resulting from the formulas.

Marketing Costs Adjustment

Theoretically, wholesale prices of butter and nonfat dry milk solids should be reduced by the costs of marketing incurred between country points and wholesale markets. In practice, such an adjustment may not be absolutely necessary and certainly it would be difficult to make. Recent studies of butter marketing indicate that central butter markets generally underquote the market for butter. 9/ Most butter plants in the North Central Region, the primary butter manufacturing region in the country, regularly sell butter at premiums over some central market quotation, but net prices received by creameries are generally slightly below these quotations because of marketing charges. The premiums and marketing charges, however, vary so much and seemingly so illogically among plants that an accurate estimate of an average difference between wholesale and country point prices would be difficult to make. Also, the net adjustments of wholesale price quotations probably would be small in relation to the price of butter. For these reasons, the unadjusted averages of wholesale prices seem to be satisfactory substitutes for country plant prices in the recommended formula when the latter are not readily available.

9/ Cook, H. L., and others, "Butter Pricing and Marketing at Country Points in the North Central Region," Minnesota Agricultural Experiment Station Technical Bulletin 203 (North Central Regional Publication No. 26), June, 1952. Of interest also is a closely related study by March, R. W., and Herrmann, L. F., "The Establishment of Central Market Butter Prices in Chicago and New York," Marketing Res. Rep. No. 53, Production and Marketing Admin., U. S. Department of Agriculture, 1953.

The Hundredweight Plan

Since the primary objective of the recommended pricing plan is to establish accurate prices for milk of various solids content, it would be reasonable to propose that milk solids be priced directly. This would be an ideal procedure if a satisfactory test for nonfat solids in milk were available. Unfortunately, a test having the necessary accuracy, speed, and low cost for practical use in milk plants has not yet been developed. Therefore, known average relationships between the fat and nonfat solids tests of milk must be used. 10/

A "fat-skim" pricing plan might also have been developed. In practice, however, there would be little, if any, basis for choosing between the "fat-skim" plan and the hundredweight plan. The two plans can provide identical schedules of prices to handlers or producers and they are about equally flexible and simple to administer. The hundredweight plan was used in the development of the formulas recommended above simply because this type of pricing plan is more generally known and used in the milk industry.

Butter and Powder Yields

To translate prices of butter and nonfat dry milk solids into values of milk of various solids content it is necessary to know average yields of these products obtainable under average operating conditions in butter-powder manufacturing plants. The yield data shown in Table 1 are based on (1) the fat-nonfat solids relationships found by Jack and associates in California and (2) estimates of product yields in several recent studies of butter-powder manufacturing plants.

When milk fat is separated from whole milk and made into butter there normally is (in trade parlance) an overrun of about 22 percent. That is, a pound of pure fat yields 1.22 pounds of butter. This yield ratio is less than the theoretical maximum yield since it allows for a small tolerance above 80 percent in the fat content of butter to make certain that the product will comply with all legal standards and for small losses of fat in the manufacturing process. On the basis of several independently conducted studies of butter manufacturing plants an overrun of 22 percent seems reasonable. Walker, et al., found an average overrun in 12 Pacific Northwest plants of 23.5 percent. 11/

10/ See Jack and others, op. cit. (footnote of Table 1).

11/ Walker, S. A., Preston, H. J., and Nelson, G. T., "An Economic Analysis of Butter-Nonfat Dry Milk Plants," Idaho Agricultural Experiment Station Research Bulletin 20.

March reports average overruns for two groups of plants in the Midwest of 24 percent and 21.8 percent. 12/ Other reported average overruns are 21 percent 13/, 23 percent 14/, and 23.9 percent. 15/

A yield of 0.96 pound of nonfat dry milk solids per pound of nonfat milk solids was selected after examination of several studies of powder manufacturing plants. 16/ This yield ratio also allows for plant losses and measurement errors encountered in normal plant operations. It is believed reasonable and practical.

Processing Cost Allowance

The allowance of 0.1 cent per test point for differences in butter-powder processing costs resulting from differences in the average fat test of milk received is based on findings made by Walker. 17/ He found that, on the average, total manufacturing costs in 1948-49 in a group of such plants rose about 0.08 cent per hundredweight of milk with each point increase in the average fat test of milk received at the plants within the range of 3 percent to 5 percent. (Table 2.) Higher testing milk costs more to process primarily because product yields per hundredweight are greater and the larger yields increase certain labor and packaging costs slightly. The allowance of 0.1 cent is used in this paper because manufacturing costs have increased considerably in the several years which have elapsed since Walker obtained his data.

12/ March, R. W., "The Pricing of Surplus Milk in the Chicago Market," USDA, PMA, Dairy Branch, November 1949.

13/ Froker and Hardin, op. cit.

14/ Frazer, J. R., Nielsen, V. A., and Nord, J. D., "The Cost of Manufacturing Butter," Iowa Agricultural Experiment Station Research Bulletin 389, June, 1952; and Bendixen, H. A., "Simplified Butter Composition Control," American Butter and Cheese Review, January 1949.

15/ State of Minnesota, Department of Agriculture, Dairy and Food Bulletin of Information, 1948.

16/ Powder yields per pound of nonfat milk solids of about 0.955, 0.974, 1.026 and 0.966 have been reported, respectively, by Walker, et al., op. cit. March, op. cit., Froker and Hardin, op. cit., and Thomsen, L. C., "Shall We Plan Toward Continued Diversification," American Butter and Cheese Review, Vol. 7, No. 3, p. 74.

17/ Walker, Scott A., "Pricing Milk to Farmers at Butter-Nonfat Dry Milk Plants," Agricultural Economics Research, U. S. Department of Agriculture, Vol. 5, pp. 85-7, October 1953. This article is based on the study by Walker and others, op. cit.

Table 2.--Estimated costs of processing whole milk of various fat tests in butter-powder plants, 1953 1/

Fat test of milk	Total processing cost per cwt. 2/
Percent	Cents
3.0	69.0
3.5	69.5
4.0	70.0
4.5	70.5
5.0	71.0
5.5	71.8
6.0	73.2

1/ Based on Walker, Scott A., "Pricing Milk to Farmers at Butter-Nonfat Dry Milk Plants," Agricultural Economics Research, U. S. Department of Agriculture, Vol. 5, pp. 85-7, October, 1953.
2/ Excludes costs of milk purchased and costs of selling and distribution. Includes, however, costs of packaging butter and powder in bulk containers.

A processing cost allowance based on total costs has the important advantage of greater accuracy over allowances based on separate costs of manufacturing of butter and powder. Use of the average difference between total manufacturing costs avoids the inaccuracies and arbitrary results which almost always follow from cost allocations in joint-product plants.

Handler vs. Producer Differential

The recommended plan provides for two types of comparable butterfat differentials. One of these applies to producer blend prices. This differential is equal to the computed net farm value of 0.1 pound of milk fat plus .044 pound of nonfat solids, adjusted by the ratio of the blend price to the price of milk of equal test used for butter and powder production. This method is similar to the one developed by Froker and Hardin 18/, except for the treatment of processing costs noted above.

However, application of this same type of differential to the use-class prices paid by handlers can constitute a serious error in pricing. This is because physical relationships between fat and nonfat milk solids are not the same in standardized milk as they are in

18/ Froker and Hardin, op. cit.

milk as it comes from a cow. Dealers in processing various fluid milk products start with the mixture of milk they receive from producers which in most markets is in the vicinity of 3.5 percent to 4.0 percent fat.

When a hundredweight of milk testing 3.5 percent fat and 8.622 percent nonfat solids is separated, say, into 10 pounds of 35 percent cream and 90 pounds of skim, the latter will contain about 8.041 pounds of nonfat solids. The remaining 0.581 pound of nonfat solids is in the 6.5 pounds of skim milk which is part of the cream. 19/ In other words, a hundredweight of skim milk derived from 3.5 percent milk has 8.94 pounds of nonfat solids while a hundredweight of 35 percent cream contains only 5.81 pounds of nonfat solids.

If the producer fat differential, which is based on the solids relationships of natural milk, were applied to standardized milk it would price skim milk as if it contained only 7.09 pounds of nonfat solids instead of 8.94 pounds. Some years ago when nonfat solids were valued at only 5 cents per pound (or less) this meant that skim milk was undervalued only about 9 cents per hundredweight. At the present time, however, the undervaluation would be much greater, and the more valuable nonfat milk solids become the more serious this pricing error will be.

Application of the producer differential to class prices would, of course, overprice standardized milks and creams having fat tests above 3.5 percent. Thus, 35 percent cream would be priced as if it contained 22.48 pounds of nonfat milk solids instead of 5.81 pounds. At current prices cream would be overpriced about 2 1/2 cents per pint, and at higher values of nonfat solids the pricing errors would be larger.

Adjustment of Class I Differential

The recommended method of adjusting the amount of the butter-powder fat differential by the ratio of the Class I price to the butter-powder value of milk of equal fat test is admittedly arbitrary. But it provides a more satisfactory and accurate differential than other known schemes under "normal" conditions when supply-demand forces affecting relative supplies of fat and nonfat solids are in approximate balance.

Class I prices are higher than manufacturing milk prices presumably by the amount of a premium for quality which in this case refers to certain bacteriological and health standards. There is no logical

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19/ The mechanical process of separating milk into cream and skim milk does not affect the ratio of nonfat solids to water in the serum (skim).

reason for arguing that this quality premium is paid to get higher quality nonfat milk solids than that it is paid to get higher quality fat solids. It is paid to get high quality whole milk.

Clarke and Tinley, following this line of argument, recommend that a schedule of prices for milk of various fat tests be computed based on manufacturing milk values and that a constant premium be added to each value. 20/ They argue that by this procedure the premium is placed on the whole milk where it belongs. However, the actual effect of the method is to increase the value of the skim portion of milk by the full amount of the premium, leaving the differences between the prices of whole milk of various fat tests at the manufacturing milk price level.

A similar result is obtained when the butterfat differential applicable to the Class I price is about the same as the differential applicable to the Class II (manufacturing milk) price, say, 12 percent of the wholesale price of butter.

The reverse of these methods is to raise the fat differential by the ratio of the value of fat in Class I and in the butter-powder formula. This has the effect of adding all of the Class I premium to the fat portion of the milk and leaving skim values in Class I at their manufacturing milk levels.

The recommended method apportions the Class I premium to the fat and skim portions of whole milk on the basis of their relative values in nonfluid uses. This seems to be a reasonable and logical compromise between the more extreme procedures of allocating all of the premium to either of the two portions of milk. Also, in the long run, since such a differential is affected by the prices of both fat and nonfat solids it is likely to function more successfully in maintaining a workable balance between supplies of milk fat and skim milk in a market. This, of course, does not imply that, under conditions of a serious imbalance, lower or higher fat differentials would not be justified for at least relatively short periods of time.

For essentially similar reasons, the recommended producer differential is the butter-powder differential adjusted upward by the ratio of the blend price to the butter-powder value of milk at the actual test of all milk received.

DEFICIENCIES IN CURRENT METHODS

Fluid milk markets employ many formulas for fixing butterfat differentials. Analysis of these devices shows that most of the common methods establish incorrect price relationships between milks of

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20/ Clarke, D. A., Jr. and Tinley, J. M., "Bases for Payment of Milk," California Agricultural Experiment Station Mimeo., January 28, 1948.

various solids content. In many instances these errors in pricing, although small at the present time, will increase greatly if values of nonfat milk solids rise in relation to milk fat values.

A Constant Percentage of the Price of Butter

By far the most common formula for fixing amounts of butterfat differentials simply provides that a differential shall be a given percentage of the price of a pound of butter. The percentages vary from about 10 to 14 depending upon the market and on the basic price with which the differential is associated. The most common rate is 12 percent. Higher percentages than this are seldom used for producer differentials or for Class II (nonfluid) uses. The butter price most frequently used as a base is the wholesale price, carlots, 92-score butter, Chicago.

The principal advantages of this method are its simplicity and its flexibility. The formula is also reasonably accurate in the pricing of milk for manufacturing uses. These factors perhaps account in large measure for its apparent popularity. The method appears to be less accurate in setting Class I and producer differentials. More specifically, the simple formula of 12 percent of the wholesale price of butter seems to be a satisfactory substitute for the recommended handler differential for nonfluid uses of milk. The two formulas provide essentially equal differentials over a sizable range of butter and powder prices. This, however, is not true for simple formulas with rates either higher or lower than 12 percent.

On the other hand, the simple formula is much less satisfactory when applied to Class I or blend prices. In the case of Class I prices, the simple formula without adjustment usually will set lower differentials than are warranted by economic conditions in the market. For blend prices, use of the simple formula is wrong on more basic grounds. The formula implies that values of nonfat milk solids are of no practical importance in establishing fat differentials. This assumption was accurate, at least in a practical sense, only when nonfat milk solids had slight value. The assumption, therefore, is no longer correct.

Paradoxically, the resulting error is overpricing of low-fat milk and underpricing of high-fat milk. For example, employing the computations on page 10, the recommended formula establishes a producer fat differential of 8.4 cents, compared with 6.8 cents using the simple formula. If milk is quoted on a 4-percent-fat basis, 3-percent milk is priced 16 cents per hundredweight too high by the simple formula and 5-percent milk is priced 16 cents too low. These differences would increase if the price of powder rose while butter prices remained unchanged. The differences would also be larger if the blend price in relation to the butter-powder value were higher. Price differences of

15 cents or more per hundredweight of milk probably are of some consequence to farmers shipping to fluid milk markets since most of them market several hundredweight of milk daily.

Fixed Fat Differentials

A few markets use fat differentials fixed in dollar amounts. Such differentials are simple to administer and occasionally may be accurate and equitable. More often than not, however, the completely inflexible nature of fixed-dollar differentials is likely to made them inaccurate and inequitable under dynamic economic conditions. Such differentials simply do not change when economic factors demand change, and the result is distortion of price relationships among milks of various fat tests.

For example, assume a price of $4.00 per hundredweight for milk testing 4-percent fat and a fat differential fixed at 10 cents per point. Assume, also, that in response to general economic conditions, which in no way affect the relative demands for milk fat and nonfat milk solids, that all dairy product prices rise 25 percent. The fixed differential, however, instead of maintaining the former price relationships--proper under the assumption made here--causes the prices of low-fat milk to rise substantially more than 25 percent. Prices of higher testing milk increase less. Thus, the price of 3-percent milk would increase from $3.00 to $4.00, or 33 percent, while the price of 5-percent milk would increase only 20 percent from $5.00 to $6.00. In the reverse situation of a general fall in milk prices, the decline in prices of high-fat milk would be less percentagewise than the decline in prices of low-fat milk. Such changes in price relationships for milk of different fat tests might lead in time to unwanted changes in the average fat test of milk received from farmers. The changes might even produce actual, as well as relative, shortages of either milk fat or skim milk with consequent undesirable effects on marketing efficiency and returns to dealers and producers.

A Constant Percentage of Basic Class Prices

At least one market, New Orleans, has the equivalent of a Class I fat differential set at a constant percentage, 1.71875 percent, of the Class I price. This procedure has the merit of partial flexibility. It is also a simple plan. The major fault of the method, however, appears to be the constant relationships that prevail among the prices of milk of various solids content.

In developing the recommended formula, the principle was established of pricing milk fat and nonfat solids on the basis of their values as determined in competitive markets for manufactured dairy

products. Fixed-percentage fat differentials violate this principle as much as do fixed-dollar differentials.

If the price of milk rises because of an increase in the demand for nonfat milk solids, one may reasonably ask why any portion of this price increase should be attributed to milk fat. This, of course, is exactly what a differential fixed at a constant percentage of the price of whole milk does. In such a case, this type of differential raises cream prices too much and low-fat milk prices not enough. Conversely, when nonfat values fall, skim values are not reduced sufficiently and cream values are reduced too much. In short, inaccurate price relationships result because they are held constant even though economic conditions demand that they change.

Fat-Minus-Skim-Value Differentials

Several fluid milk markets using "fat-skim" methods of accounting for milk compute producer butterfat differentials by deducting the blend price for skim milk from the blend price for milk fat. The result is then divided by 1000 since there are 1000 fat points per hundredweight of fat.

This method implicitly assumes that all whole milk delivered by farmers contains uniform quantities of nonfat solids. But there are available many data that show that the nonfat solids content of milk increases (less than proportionally) as the fat content increases. 21/

An increase in the value of skim milk under a fat-minus-skim-value method reduces the amount of the producer fat differential. Under the recommended formula, however, the differential would be increased, in recognition of the presence of additional nonfat solids associated with additional fat. Since fat differentials are added to or subtracted from the price of standard-test milk a differential that is too small overprices low-fat milk and underprices high-fat milk. Therefore, as skim milk values rise relative to fat values the fat-minus-skim-value method will err considerably more than at present (which is not much at prevailing prices of fat and nonfat solids).

Direct-Ratio Differential

The antiquated system of pricing milk on a direct-fat-ratio basis is used today in only a few fluid milk markets. The method has largely been abandoned because it greatly overvalues milk of high fat content and undervalues milk with a low fat test. The extent of the errors can easily be illustrated.

21/ Jack, et al., op. cit. and Jacobson, M. S., "Butterfat and Total Solids in New England Farmers' Milk as Delivered to Processing Plants," Journal Dairy Science, Volume 19, pp. 171-76, 1936.

Assuming butter and powder prices of 57 cents and 15 cents and a manufacturing allowance of 70 cents, the price of 4-percent milk becomes $3.35 per hundredweight. This, in a sense, is equivalent to $0.84 per pound of milk fat or a direct-ratio differential of 8.4 cents per point. The recommended formula, in contrast, provides for a differential of 6.8 cents for handlers. The direct-ratio method prices skim milk to handlers at zero compared with 63 cents under the recommended procedure. In the case of 40-percent cream the direct-ratio method is too high by $5.67 per hundredweight, or 6 cents per pint. Differences would be even larger at higher prices.

As values of nonfat milk solids rise in relation to fat values the direct-ratio method becomes less and less satisfactory. The method encourages the production of high-fat milk at the same time that it discourages sales of cream by dealers and promotes sales of skim milk items. In short, it is out-of-date and has no place in the pricing structures of modern fluid milk markets.

Milk Equivalent With Reconciliation

In the Chicago, Milwaukee, and Topeka markets, milk in Class I is accounted for on a volume basis without regard to fat content. Milk in the remaining classes is accounted for on a milk-equivalent (of milk fat) basis. The sum of these quantities usually differs from the volume of milk actually received from producers. A reconciliation (addition or subtraction) is, therefore, made in the class having the lowest price.

Computation of fat and skim values under such a pooling system is not simple and the results may appear unusual. The Office of the Chicago Market Administrator has developed a method whereby Chicago dealers can estimate their raw product costs for products having various fat contents. The procedure is as follows:

The Federal Order governing the Chicago market provides the basic formulas for computing prices for the 4 classes of milk of 3.5 percent fat test and the producer fat differential. The computation of the skim value in Class I is the Class I price for 3.5 percent milk minus 35 times the fat differential. The fat value per hundredweight is the producer butterfat differential times 1000 plus the value of 100 pounds of skim milk as computed above. The fat and skim values in Class IV are computed in the same manner.

The values in Classes II and III, however, are computed differently. Because milk is accounted for in Classes II, III, and IV on a milk-equivalent basis, the price differences among the classes

must be attributed to the fat. In other words, the price of skim remains the same in all 3 of these classes. Therefore, the fat value in each class becomes the class price less the Class IV skim value divided by 35, multiplied by 1000, and finally with the addition of the skim value. An illustration is as follows:

Assume class prices of: I, \$4.50; II, \$4.30; III, \$3.50; and IV, \$3.30; and assume a producer differential of 8 cents per point. The Class I value of 100 pounds of skim milk is then \$1.70 which is \$4.50 - (35 x .08). The value of 100 pounds of fat is \$81.70 which is (.08 x 1000) + \$1.70. The Class IV skim value is 50 cents, or \$3.30 - (35 x .08). The fat value is \$80.50, or (.08 x 1000) + .50. The Class II and III skim values are also 50 cents per hundredweight. However, the Class II fat value is 109.07, or (\$4.30 - .50) ÷ 35 x 1000 + .50, and the Class III fat value is \$86.21. These values are essentially equivalent to the class prices coupled with fat differentials of: I, 8 cents; II, 10.9 cents; III, 8.6 cents; and IV, 8 cents.

With any given set of basic class prices the Chicago procedure will give producers more money than any other type of pricing system. The reasons for this are quite simple: The relatively low-fat fluid milk products are classified in Class I where skim milk has a very high value in relation to skim values of other classes. And Class II contains all of the high-fat fluid items and carries the highest fat price. Whether or not such a pricing scheme actually gives farmers greater gross returns over time is a debatable issue. At least Chicago blend prices are not usually higher than blend prices in cities immediately outside its milkshed.

The method has little else to recommend it. It is highly complicated. The fat and skim values are not logical in comparison with results under the recommended formula. It is flexible but in a rather peculiar way. For example, a fall in the price of butter will cause the producer differential to decline and this, in turn, tends to cause skim values to rise provided that the class price does not change directly with the price of butter. The recommended plan provides a much more internally consistent, logical, and practical set of values for milk fat and nonfat milk solids.

FINAL APPRAISAL

The recommended formulas for setting price differentials for milk of various solids content are designed more for the future than for the present. Price differentials in only a few city markets are now seriously out of line with current economic conditions affecting values of milk solids.

The principal merit of the formulas, however, is their capacity to alter automatically the relative prices of milk of various solids content as economic developments change relative market values of milk fat and nonfat milk solids. All pertinent economic signs indicate that the value of nonfat milk solids is likely to rise gradually over time in relation to values of milk fat.

For this reason, it is important to have available a pricing method which will alter milk price differentials promptly and accurately as future economic developments require. Failure to modify many existing fluid milk pricing plans may, in time, create serious imbalances in supplies of milk fat and nonfat milk solids, marketing inefficiencies, and inequities. The recommended formulas provide the mechanisms needed to alter milk price differentials automatically as future economic conditions change.